OCCURRENCES OF THE ASPHALTIC SUBSTANCES IN SOUTHEASTERN TURKEY AND THEIR GENESIS

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ABSTRACT.— In an area of approximately 17,200 km^2 in Southeastern Turkey a prospection was carried out in all parts where occurrences of asphaltic substances could be expected in accord with the stratigraphical-tectonic situation. The author describes the vein-like occurrences, partially explored by trenches and drillings, which attain a length of up to 3500 meters (Avgamasya and Milli veins) and locally a width up to 80 m (Avgamasya vein).

The author arrives at the conclusion that tectonic events, such as upthrusts and overthrusts, caused the opening of often irregular systems of deep-reaching, broad, gaping fissures. In particular, tilting of strata below the overthrusts was observed, whereas diagonal fissures are a very striking feature of the hanging parts. Soft masses of asphalt originating from a former oil horizon, intricately mixed with mineral substance, were squeezed into these fissures right up to the surface region, under the pressure of overlying rock masses.

An «asphaltic pyrobituminous shale» in the «Cudi group» was recognized as one of the ancient oil horizons.

INTRODUCTION

In accord with the efforts of the Turkish Government to explore the areas of Eastern Turkey for new and productive occurrences of solid fuel, the author investigated the occurrences of asphaltic substances in the region south of Şırnak County (Siirt Province) on behalf of the Mineral Research and Exploration Institute of Turkey, from 1964 until 1967; occurrences to which hardly any attention had been paid so far, but which can be used as a fuel like good coal. In the same time a prospection was carried out in an area of approximately 17,200 km^2 in all parts where occurrences of asphaltic substances could be expected in accord with the stratigraphical-tectonic situation.

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A short geological outline illustrated by a map and a description of the single occurrences of the asphaltic substances will be given. Finally, some problems, especially the question of provenance and origin of the occurrences of asphaltic substances will be discussed.

1. GEOLOGY OF THE AREA OF OCCURRENCE OF ASPHALTIC SUBSTANCES

The area in which most of the occurrences of asphaltic substances are concentrated, is shown in the outline map of a part of Southeastern Turkey in Plate I.

The stratigraphical members found in this area were investigated and described by numerous geologists. As the most important ones, reports by Altınlı (2-5), Blumenthal (9, 10), Schmidt (35), Taşman (41, 42) and Tolun (44-46) can be cited.

Since the stratigraphy does not seem to be of great importance for the formation of metamorphic asphaltic substances, which will be discussed in this paper, the following short outline may be sufficient.

The oldest member is the *Devonian* east of Harbol. The overlying *Harbol fm.* belongs to the Permian and consists of limestones with four intercalated quartz-sandstone beds. It is likewise found near Harbol. Then follows the *Goyan group* belonging to the Triassic (Werfenian). It consists of thin-bedded limestones, lime-shales, purple and red-brown shales, in the upper part mainly grey and dark-grey shales with thin beds of dolomite. Most important for the following discussions is the *Cudi group,* regarded in its lower part as Middle Triassic and in its hanging part as Middle or Upper Cretaceous. It consists of a thick sequence (about 1000 m) of mostly dark, fetid limestones, dolomitic limestones and dolomites. The middle portion contains an intercalation of black bituminous shale of up to 10 m thickness. It will be discussed later on under the heading «Asphaltic pyrobituminous shales». The Cudi group follows the *Germav fm.,* a sequence of 1600 to 2100 m thickness, divided by Nebert (32) into a «Lower, Middle and Upper Şırnak fm.» and a «Lower and Upper Germav fm.». The lithology and age divisions are shown in detail in the legend of Plate III. In the hanging of the Germav fm. follows often, but not everywhere -—for example not in the region of Harbol— the *Becirmen limestone* (20-200 m) belonging to the Paleocene. A sudden change into red colors announces the terrestrial deposits of the *Gercus, fm.* with sandstones, conglomerates, red clays and in the hanging parts soft grey and yellowish marls and clays with gypsum. The sequence is about 800-1300 m thick. The most widespread formation, the *Midyat fm.,* consists mainly of marine limestones (Lutetian). The rest of the younger formations is not of great interest. The *basalts* belong to the Pliocene.

More important than the stratigraphy of the area are the *tectonic structures.* In the outline map are shown the main features, the anticlines, faults and overthrusts, established in the course of oil researches. It appears plausible that occurrences of asphaltic substances can only be found in such places where tectonic movements had opened deep-reaching fissures which could be filled by liquid asphalt. Details shall be discussed in the description of the individual occurrences.

II. THE OCCURRENCES OF ASPHALTIC SUBSTANCES

By «asphaltic substances» the author understands all natural residues of asphaltic petroleum, disregarding whether they were found in primary or secondary deposits, associated with mineral substance or not, chemically altered or not. If

the term «metamorphosis» is used in the following explanations, the author means, in concert with Abraham (1, p. 92), the transformations» of the petroleum residues not only under the influence of time, heat, and pressure, but also as the result of the complicated chemical processes.

In the following, the individual occurrences will be described first, numbered in the same manner as in the maps. Our investigations have shown that they can be grouped corresponding to the tectonic units. These relations will be discussed in detail in the following chapter.

A. ASPHALT IN THIN FISSURES

During the extensive prospections for metamorphic asphaltic substances in a territory which reaches far beyond the area shown in the map on Plate I, occurrences of pure asphalt were found in numerous places in thin fissures, sometimes clustered—as near Germav and west of Gercüş.—and frequently also infiltered into permeable rocks. They were marked by a large dot on the map, but they will not be a subject of further discussions.

B. OCCURRENCES OF ASPHALTIC SUBSTANCES IN VEINS

In the following the individual occurrences of asphaltic substances in veins will be described, grouped corresponding to the «tectonic units». General conclusions concerning their origin will be given in the end.

a. Occurrences originated in and below overthrust or upthrust planes

One of the most interesting overthrusts of Southeastern Turkey is doubtless the overthrust on the southern border of the Cudi Mountain (more than 60 km long), shortly named Cudi Overthrust.[1] It can be followed in WNW direction, ascertained in parts, and partly conjectural, as far as 18 km west of Kerburan, that is, for another 50 km (Plate I). For a length of about 50 km it is developed as a twin overthrust. Steeply dipping limestones of the Midyat fm. occupy the space between the two overthrusts. In the western part of the northern overthrust, which is the more important one, only the Cudi group and the Germav fm. are in contact with the Midyat limestones, but in the eastern part near Harbol limestone complexes of the Cudi group make their appearance, and below them the Triassic sequences of the Goyan group, the Permian sequence of the Harbol fm. and, concealed in parts, also the Devonian (east of Silip village, see Plate II). There, the Germav fm. and the Gercüş fm. remained below the overthrust, and the Midyat fm. was steeply upturned (see Fig. 1).

The Harbol, Beşiri and Kasrok veins occur in this zone of overthrusts.

1. The Harbol vein.— The occurrence of an asphaltic substance at Harbol (Mardin Province, Silopi County) was visited first by Prof. Granjean in 1922.[2]

The first short description was given by Lucius (28) in 1929. Later on, the occurrence was either registered only in maps and profiles or described in more detail in mostly unpublished reports of the M.T.A. Institute, by Moses (31), Maxson (29), Foley (14), Lokman (26), Cunningham-Craig (12), Clapp (11), Blumenthal (10), Ortynski and Tromp (34) and others. According to the report by Lokman (27), the material was mined as «coal» since the seventies of the last century until the end of World War I, and transported to Mosul. It was used as fuel on the steamers sailing on the Tigris between Mosul, Baghdad and Basra.

The first explorations by means of trenches were made by Foley (14) in 1938, by galleries (Mining Engineer B. Çutay) in 1946—described by Atabek (7)—and finally by means of more trenches by Lebküchner and Ünyay (21) in 1966.

Immediately below the steeply dipping limestone beds of the Midyat fm. on the SSW slope of the valley (see Plate II and Photograph no. 1) is a vein of an asphaltic material in the red, soft and clayey layers, close to the border against the sandstone layers of the Gercüş fm., mostly covered by talus. Until to-day the vein can be traced for a length of about 1600 m. The vein runs in WNW-ESE direction with a nearly vertical dip. The width of the vein averages 20 m, but widths of 3 m and 26 m were also observed.

So far, our investigations did not permit exact statements regarding the local swelling and pinching and branching of the vein, such as they were described later on at the Avgamasya vein. Remarkable observations were only made by Atabek (7) in the galleries in the ESE-section of the vein, where he said, «faults» were found. Two of these could be interpreted as transcurrent faultings according to the sketch given by Atabek. Blumenthal (9) regards them as «younger disturbances» since «brecciae» were found in the asphaltic mass. But it is a well-known fact that tension cracks often show zigzag shapes and broken portions of the vein walls and rock fragments can drop into the ascending soft asphalt mass, thus assuming the appearance of a tectonic breccia, as was established by investigations of the Avgamasya vein.

A second, though not so important vein is found at the entrance to the gorge of the Yumurtalık Creek, about 750 m north of Harbol village. In hard crushed marls of Germav fm. immediately above the thrust plane a vein more than one meter wide, of an asphaltic substance, which is completely disintegrated to a powdery substance, is observed (marked «A» on the map in Plate II). Clapp (11) mentioned this occurrence and Schmidt (35) has shown it in his profile.

The asphaltic material of the main occurrence was formerly termed «asphalt» (26, 9, 34) or «manyak» (11) or, more correctly, «asphaltic pyrobitumen» by Foley (14). Foley considers the term «asphaltite» as questionable. It was termed «harbolite —a carbonaceous hydrocarbon» by Cunningham-Craig (12) quoted by Ta§man (39, 40). The material resembles pitch coal, as correctly described by Blumenthal (10); it is dull-bright, brittle and displays conchoidal fracture. F. Orhun (33, table IV) has tested and described the material and termed it «substance between asphaltite and asphaltic pyrotlitumen (associated with mineral matter)». The material of the little occurrence-immediately below the overthrust was equally

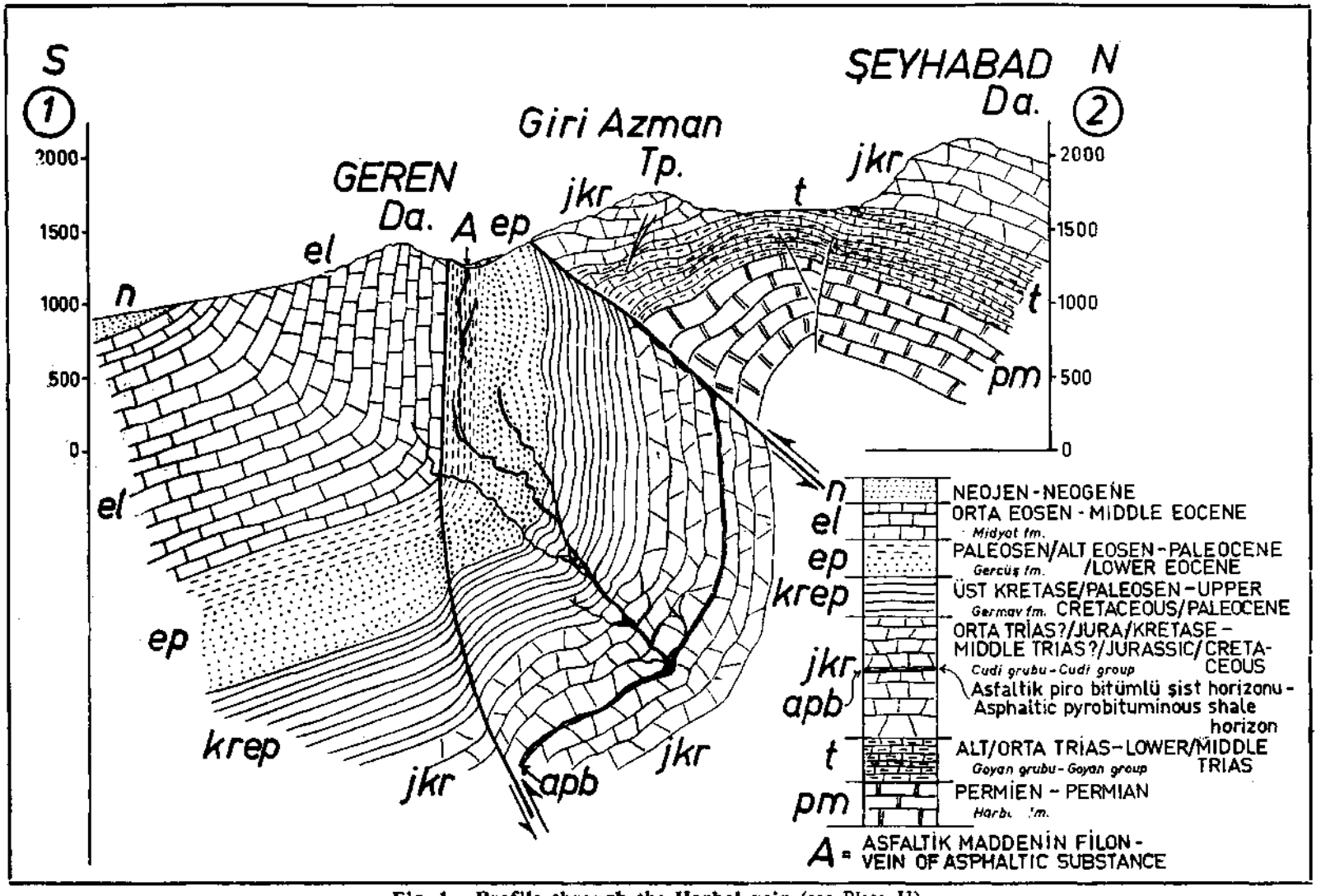

Fig. 1 - Profile through the Harbol vein (see Plate II).

tested; it shows a much more progressive metamorphosis and was termed «asphaltic pyrobitumen (associated with mineral matter)».

The diagrammatical profile (Fig. 1) shows how the origin of the Harbol vein can be explained. A detailed explanation is not considered as necessary.

2. The Beşiri vein. — Prospecting in summer 1966 along the Cudi overthrust from Harbol westwards, the Beşiri vein was discovered by Aytaç Gülay (23). North of Beşiri village (Mardin Province, Silopi County) in a little side valley of the Sergelya Creek he found a series of outcrops of an asphaltic substance exposed by erosion in coarse detritus. There too, the vein occurs in the red Gercüş fm. (see Plate II). It can be traced for a length of about 100 m, the width could be more than 10 m. The vein can be considered as the continuation of the Harbol vein.

The vein material, altered by strong and permanent influence of the weather, is termed «asphaltic pyrobitumen (associated with mineral matter)» by F. Orhun (33, plate IV).

3. The Kasrok vein.— Looking at the Photograph no. 2 and the map in Plate II, we can see the Midyat-limestone-wall of the Geren Mountain crossing the Hezil Suyu and continuing in the Kera Mountain in Iraquian territory. Also the red Gercüş fm. runs parallel to this wall. Trustworthy inhabitants of Harbol have brought samples from an outcrop situated SW of the village Kasrok (Iraq). The tests made by F. Orhun (33, table IV) gave the same result as the material from Harbol.

There is no exact information about length and width of the vein.

4. The Kalük -Şivit vein. — 24 km east of Şırnak near Sekerek village begins an overthrust line (see Plate I), which can be pursued for a length of more than 40 km south of Uludere (Hakkari Province) and close to NE of the villages Delakan - Kalük - Şivit - Gerur - Becuh. The limestones of the Cudi group are thrust onto or over the well-bedded bluish and greenish marls with intercalated sandstones and calcareous marl beds of the Germav fm.

During the first prospecting work, carried out along the Gerur overthrust in summer 1966, A. Gülay and E. Ercan have found an occurrence of asphaltic substance situated between the villages Kalük and Şivit (24) (Uludere County, Hakkari Province). Three outcrops scattered within 50 m doubtless belong to one vein. The line forms an acute angle with the direction of the overthrust in this region. In a trench, dug in one of the outcrops, the width of the vein is 50 cm. The vein seems to have much greater dimensions, perhaps below a thin covering. In Fig. 2 a diagrammatic profile through the occurrence is shown.

The material of the vein consists of a black, earthy mass, that is, a material already considerably altered due to weathering. It was placed by F. Orhun (33, table IV) in the group of «asphaltic pyrobitumen (associated with mineral matter)».

5. The Gercüş veins.— On the southern border of the Gercüş anticline (see Plate I and Fig. 3), according to the maps of the «Esso Standard Inc.», there are some upthrusts in the red Gercüş fm. running about E to W. It is supposed that

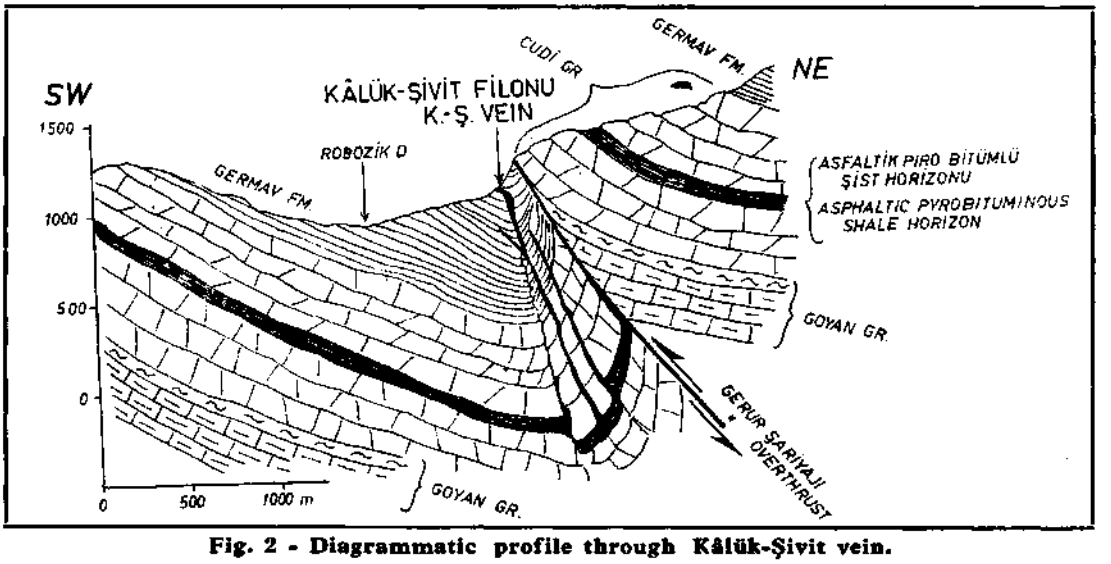

Fig. 2 - Diagrammatic profile through Kâlük-Şivit vein.

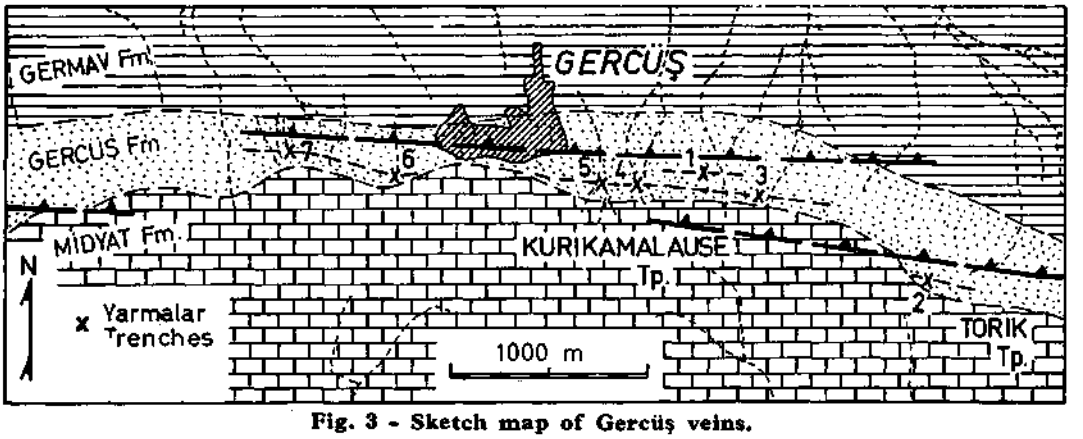

Fig. 3 - Sketch map of Gercüş veins.

the zone of disturbance has in reality a much more complicated structure. Due to the cover of talus (there are vineyards, in places), the clearing up would be very difficult.

In this zone of disturbance three veins of an asphaltic material were exposed by trenches dug under the supervision of G. Kaynak in 1965 (17). Some outcrops were already known by Moses (31), Kirk (15), Maxson (29), Lokman (26), Clapp (11) and Schwennen (36). The longest vein between the trenches no. 3 and 7 (Fig. 3) has a length of 2400 m. The widths of the mostly steep-dipping veins are changing between 1 and 2 m.

A sample of the trench 1, made in 1964 (16), was tested. F. Orhun (33, table IV) has placed the asphaltic material in the group of «substances between asphaltite and asphaltic pyrobitumen (associated with mineral matter)».

6. The Teffi vein. — East of Gercüş (County seat, Mardin Province) in the surroundings of the villages Habesbeni and Teffi, there appears in an anticline the obviously very disturbed red Gercüş fm. below the limestones of the Midyat fm.

During the prospecting work carried out in 1965 NE of Teffi village a little vein-like occurrence of asphaltic substance (17) was found in the Gercüş fm., closely resembling the material of the Gercüş veins. Because of landslides, extensive trenching was impossible.

b. The veins in the hanging part of the Cudi overthrust

Up to now the most numerous, biggest and most economic veins of asphaltic substances occur in the hanging part of the Cudi overthrust (see Plate 1). The geological sketch-map (Plate III) shows the six most important occurrences. The stratigraphical build, including the facies units and the age division, can be taken from the legend of the map.

Outside the territory of the map in Plate III are situated the veins of Herbiş, Gündüküremo, Dergül and Navyan. They are only shown in the outline map in Plate I.

In the following part the occurrences shall be discussed according to their importance.

7. The Avgamasya vein. — About 8 km SW of Şırnak (County seat, Siirt Province) and close to Avgamasya village is situated the biggest and up to now the best explored, but relatively late known occurrence of an asphaltic substance. It was formerly regarded as coal by the local population and used to burn lime; for several years it has been and still is mined in open casts (see Photographs no. 3 and 4) and transported as «domestic fuel» to Diyarbakır and other larger towns in the East of Turkey. The first citations are to be found in Maxson (29), who shows photographs of two «manyak» occurrences (today's open cast on the creek border in profile 8 of Plate IV and little side veins on the creek border in profile 5), in Ortynski and Tromp (34) who note an «asphalt» occurrence at «Çelik Savati» (an old term on the NE-end of the Avgamasya vein), and in Altınlı (2), who shows in a photograph at «Çelgeşevati» (he features of a partially burned «asphalt» outcrop in the Germav fm. with scoriae (exact point : Plate IV at profile 17).

On the strength of a note by Wippern (47) in 1961, first investigations were made by Nebert (32) in autumn 1963. Thereafter, explorations were made to an average depth of 125 m (deepest drilling 1A — 236 m) in the years from 1964 to 1967. 75 trenches, partially of greater dimensions, were dug, 131 flat drillings were made to find out the widths of the vein below terrace gravels and other overburden of increasing thickness, and 15 vertical as well as 16 inclined drillings were made (altogether 4911 drilling-meters) to find out the shape of the vein in depth. The results of the investigations (18) are shown in the sketch-map of Plate IV, omitting the covering gravels and soil, and in 19 profiles through the drillings and vertical to the strike of the vein or the vein parts.

The Avgamasya vein cuts from SW to NE the hard, compact, marly limestones of the Upper Şırnak fm., the soft marls of the Lower Germav fm. and ends in the well-bedded marls with hard sandstone layers of the Upper Germav fm. (cf. Plate III). Its total length amounts to 3500 m (2800 m examined by exploration work, 2300 m are mineable),

In the last section (NE) which is dissected by many disturbances, the intercalations of sandstone layers become copspicuous by their different manner of fracturing compared with that of the marls. Small veins of 0.40 to 1.50 m width, sometimes running in zigzag lines due to intercalations of sandstones with different mechanical properties, generally follow the disturbances and the sudden kinks of the beds.

By comparing the lines of strike on the map, going from NE to SW, with the corresponding profiles based on explorations, it becomes apparent that the constant and sudden change of width and shapes obeys no conceivable law.

The vein seems to narrow down at depth as soon as the principal side veins have joined together; only in profiles 14, 15, 17 and 18 the vein grows wider or keeps the same width in depth.

Some interesting observations and their possible interpretation shall be added:

The changing shapes, probably continuing to depth, display, in the writer's opinion, by their irregularity the character of tension cracks. In addition, huge coherent blocks of marls are met with in drillings as well as in prospecting pits, and recently in open casts. They are completely surrounded by the asphaltic mass. One can easily imagine how the cracks tear open wider and wider and at the same time the soft to half-liquid asphalt masses ascend from depth. Wedge-, board- or block-like shaped pieces of rocks are detached along fissures from the walls now forming the walls of the veins and fall into the mass, often turning in various angles as they sink down. Therefore it is not surprising to find now bedded angular fragments of head-, fist-and pea-size accumulated and «swimming» in isolated and separate portions of the asphaltic mass. Sometimes the fragments are only slightly infiltrated by asphalt and often the stratification becomes clearly recognizable, better than without such infiltration (see Photograph no. 9).

The vein walls are rarely even, but sharply limited against the vein filling, and the asphaltic material is completely free from contamination by fragments of wall rock. On the other hand, the asphaltic material shows stripes in some places, which indicates that the ascending asphaltic mass was no longer highly fluid. Subsequent movements of small extent cannot be excluded as a possible cause of these stripes.

In some smaller side veins in the northeastern zone of disturbance the grey marls are found in trenches in contact with the vein filling, soft, squeezed, loosened and slightly yellowish discolored, in a width of about 50 cm. The asphaltic mass, which is hard and shows no signs of mechanical stress, contains irregular-shaped, mostly small marl fragments impregnated with asphaltic substance.

For the rest, the main vein, where it can be delimited as such, dips steeply NW, as shown on the profiles in Plate IV.

The width of the vein shows wide variation, but widths of 20-30 m are most frequent. The utmost width is seen in profile 6. Apart from the side vein, the width is still more than 80 m.

The asphaltic substance itself was tested in detail by F. Orhun (33, tables II and IV). She classified it in the group of «substances having characteristics

close to asphaltic pyrobitumen (associated with mineral matter)». The aim of the tests of a large number of samples of drilling 1 was to find out whether the material changes its characteristics at depth. It became apparent that the material does not change its properties. The increase of mineral content with increasing depth will be discussed later on. Generally speaking, the only observable change in the asphaltic substance is the hardness of material. On the borders of the vein — excepting, of course, some very much weathered parts near the surface — and in small side veins, the material is hard throughout. In the inner portions, especially of the wider vein parts, the substance is often so brittle that it breaks into little pieces, fragments and dust in the open casts. But there are also portions where the material can only be mined by blasting with dynamite (open-cast in the Bilmat Creek, profile 13).

The question af self-ignition of the asphaltic material and the burned vein parts shall be treated later.

8. The Segürük veins. — The occurrences of Segürük (former Sigirik, Segerek, Sigirik), named after a little hill, have become known early, since they are situated about 5 km SW of Şırnak on the road to Cizre. One of the occurrences close to the road has been burning for more than the last 40 years, diffusing an intensive odor of sulphur. Lucius (28) announced lentil-shaped asphalt occurrences, Moses (31) spoke about «burning manyak» and Lokman (26), Arni (6), Clapp (11), Ortynski and Tromp (34) and Altınlı (2) have noticed the occurrences as oil indications.

On the strength of a note by Wippern (47), the first detailed investigations were made by Nebert (32) in 1963 and from 1964 to 1965 by the author (19). The result of the geological investigations and explorations, made in the most promising northern part of the occurrences by 10 trenches, 25 flat-drillings, two inclined and one vertical drillings in the years from 1966 to 1967, is shown in the sketch-map and the five profiles of Plate V.

The occurrences of Segürük, throughout situated in the area of the Upper Germav fm. (see Plate III), cannot be regarded, at least not in the southern part, as a single vein, but rather as a group of veins in a wider zone.

The most striking fact is that the whole group of occurrences does not show a strike diagonal to the thrust-direction of the Cudi overthrust, like the other occurrences, but a N-S strike. Among the numerous veins in the southern part of the zone, there are also E-W directions and noticeably twisted veins.

In order to obtain an idea of the regional structure, the variation of strike and dip of the strata was indicated on-the map by lines and arrows. In contrast to all the other vein occurrences in the hanging part of the Cudi overthrust, these lines show a confusingly erratic course, indicating a complicated system of folds which is very difficult to analyse. In this connection, the type of folding as visible at «K» (see map Plate V and Fig. 4) is quite instructive. The little fold is found on the north end of a rupture running SSE-NNW in a creek, along which the eastern part was displaced to north. Similar features, also associated with ruptures, are found here and there in the south and north, but their connection is not so clearly observable.

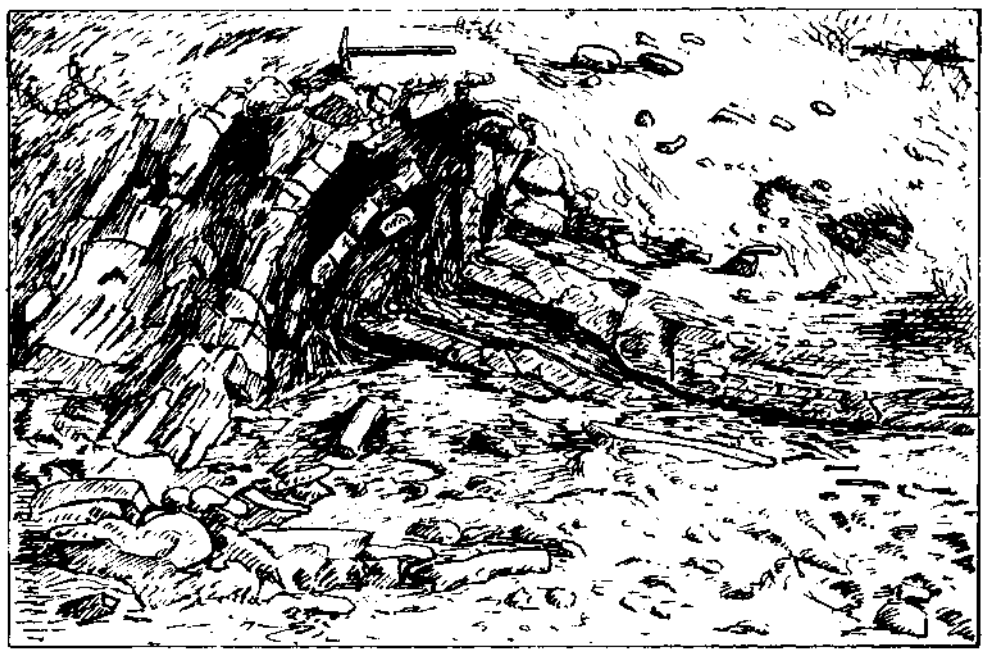

Fig. 4 - View of a typical little fold.

The whole picture gives the impression of a right-hand rotation of the disrupted blocks. The little fold at «K» could be regarded as a local feature connected with the movement of the blocks. During these movements «en echelon» fissures are likely to have opened, such as they are frequently observed in fault zones, forming acute angles with the fault plane. But this question can hardly be solved without detailed investigations especially in the south part, and on a wider scope.

The veins in south part, which will not be described in detail, show only widths of 0.10 to 2 m on the surface. They have a length of 20 to at most 200 m and are therefore without economical interest, in spite of their good quality.

In the northern part of the area, conditions are different: the strike of the veins turns there more into a SW-NE-direction. The most striking feature here is a ridge of about 500 m length, which contrasts by its red color in the landscape. It is a former vein outcrop nearly completely burned. Scoriae, sintered sandstones and brick-red and yellow burned marls create the impression of an exceptionally wide vein. From the south end the unburned vein can be pursued for about 400 m with widths of 1.50 to 2 m.

The principal vein is marked «1» in profiles I to V and on the map. Its width in the north is about 10 m. It dips WNW, whereas the veins 2-4 are dipping ESE and presumably join the main vein somewhere in the depth, as shown schematically in the profiles. The vein no. 2 begins at profile II. In a gully the head end of a vein of 3 m width was exposed originally by erosion and later on in a small open cast. In profile I it is still concealed in depth and beginning at the next glen — at the upper end of which the northernmost outcrop of the main vein is exposed— it can be pursued along the slopes as far as below the west slope of the Segürük hill dipping about 40° SE. In a likewise manner the vein no. 4,

14 m wide in profile V, remains concealed in depth in profiles IV to II; in profile 1 it is still 6 m wide, crosses the northern glen as a small ribbon and ends at the opposite slope with branches of only 5-10 cm width.

The Segürük veins have a total length of 1660 m and widths from a few decimetres to 15 m.

The asphaltic material tested by F. Orhun (33, table IV) shows the same characteristics as the material of the Avgamasya vein.

9. The Milli vein. — About 9 km SE of Şırnak (Plate III) below the villages Nerah, Kürün and Milli and south of the Nerah (or Nerakin) Creek, a vein of asphaltic substance was found running along the slopes in SW-NE direction, which became known first in 1964 (16, 17). The result of the investigations (only 23 trenches were made so far) of this vein, named after Milli village, by the author in the years from 1964 to 1967 (16, 17, 20, 21) is shown in Plate VI.

The total length of the vein, striking SW-NE in the beds of the Upper Şırnak fm. is 3500 m. One SE-NW- striking side vein has a length of 750 m.

The main vein can already be recognized from afar, that is from the road Şırnak-Uludere near Kürün, as in Photograph no. 5. Trees have grown where the easily crumbling asphaltic vein filling crops out, which are almost entirely absent on the hard marls.

Often calcite-filled fissures parallel to and NW of the main vein are running across the ridges and crossing the little creeks. Some 1-2-m wide ones were entered on the map on Plate VI. Nearly parallel to the SE-NW- striking side vein only a few little faults are apparent in the northeastern part of the area.

The widths of the main vein are indicated on the lower border of Plate VI. The maximum width was 13 m, measured in a trench (point 8). The vein, however, is split into two parts, in places, by a vertical wall consisting of marls. The breadth of the dividing wall is shown by a smaller number indicating the total width of the vein. The Photograph no. 6 shows such a dividing wall in an abandoned open cast (point 12).

The dip of the vein varies from 75 to 80° SE. In some places, for instance at point 8 and 16, where the dip could be measured exactly at both vein walls, the difference between the angles of dip on both sides of the vein is such that the vein appears to widen at depth. This widening at depth also becomes evident by a comparison of the trenches 6 and 7. In trench 7, at the top of a ridge, a width of only 3 m was observed, while in trench 6, which is not yet completed, a width of more than 9 m is visible, further down the slope.

The SE-NW-running side vein is smaller (1.20-2.50 m). It disappears below talus and landslip masses near the mill in the Nerah Creek.

The asphaltic substance of the Milli vein is an «asphaltic pyrobitumen associated with mineral matter», according to the tests of a sample from the open cast in 10 (Plate VI) made by F. Orhun (33, table IV).

10. The Herbiş vein. — About 8 km east of Şırnak and 2 km N of Milli village in 1750 m altitude on the NE-slope of a NW-SE-striking hill range, there

is an area which is locally known as «Herbiş». There, some outcrops of a vein (only in Plate I) became known in 1964 (16, .17). The vein is about 250 m long and 3.50 m wide, striking NW-SE and dipping 35° SW. It cuts the beds of the Upper Germav fm. just below the Becirmen limestones, which top the hilt range. The asphaltic substance is, according to F. .Orhun (33, table IV), the same as in the Milli vein, that is «asphaltic pyrobitumen associated with mineral matter».

11. The Seridahli veins. — About one kilometer SE of Seridahli village (Plates I and III, Fig. 5 - left sketch) (25) a vein of asphaltic substance beginning some distance behind the Gorameli ridge (1200 m) runs in the Lower Şırnak fm. in SW-NE direction down the slopes, crosses the valley of the Şildi Creek, a ridge and the Nalahiri Creek and runs from here upwards in a little side creek until 1050 m altitude. There it cuts already into the Middle Şırnak fm. Looking from a higher point, such as the summit 1207, towards SW, one can pursue the vein nearly in its whole length with naked eye (Photograph no 7). As in the Milli vein, densely crowded trees, growing in the loosened ground of the weathering asphaltic mass, mark the trace of the vein. Workers of the open-cast mine of Avgamasya have dug trenches there (shown on Fig. 5) in the winter of 1966-67.

The vein has a total length of 1750 m. Between the outcrop in 1 and the uppermost trench in 2 (= 550 m) the vein outcrop doubtless continues below the talus, if the vein fissure is not closed above. In fact the vein is proved only on a length of 1200 m.

The widths of the vein on the surface change between 1.90 and 14 m. In this vein, too, it is apparent, that its width is greater in the lower outcrops than in the higher ones.

The dip of the vein is 74-88° SE.

A second vein, more than 200 m long and more than 5.50 m wide, is running in the beds of Middle Şırnak fm., striking about E-W along a little valley N of the NE end of the main vein.

In general the asphaltic mass in the trenches is deeply weathered. Therefore, only one sample of moderately fresh material could be taken in the trench at 17. The asphaltic substance has, according to F. Orhun (33, table IV), the characteristics of an «asphaltic pyrobitumen associated with mineral matter».

12. The Ceffane vein. — Near Ceffane village (Plate I and III), exposed in some little outcrops and some trenches, a vein of an asphaltic substance was encountered, about 1175 m long, striking SW-NE, and with widths from 0.50 to 1.50 m (25). Quick changes of dip and strike of the beds of the Middle Şırnak fm. in the vicinity of the vein (not all measured dips could be shown on Plate III) indicate a zone of disturbance. The vein ends after crossing the Ceffane Creek on the slope above the Nivava Creek in the vortex of a small cracked anticline. The trace of the crack can be pursued for another 20-30 m up the slope. From thereon only calcite-filled fissures can be seen running in the same direction.

Samples were not taken, since no fresh, unweathered material could be obtained. Presumably it is also an «asphaltic pyrobitumen with mineral matter».

13. The Nivekara vein. — The Nivekara vein (25) is named after the close-by settlement «Nivekara», about 1250 m SSE from its SW end at the Ru Creek. It

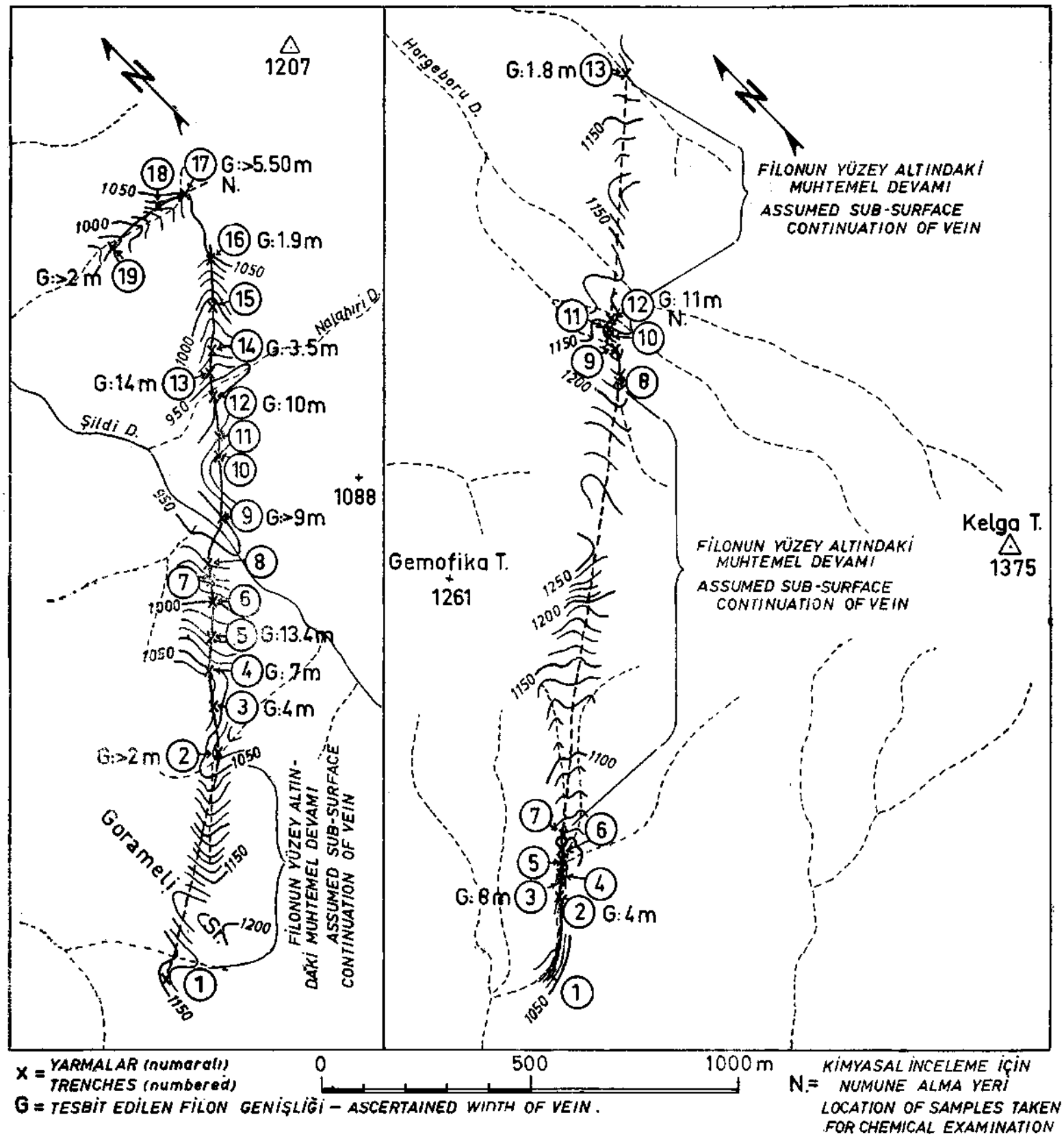

Fig. 5 - Sketches of Seridahli (left) and Nivekara (right) veins.

was exposed at the same time as the Seridahli veins in trenches made by workers of the Avgamasya open cast.

The SW-NE-striking vein begins with outcrop 1 in the Lower Şırnak fm. (Plate III and Fig. 5, right sketch) on the slopes of the valley of a creek running toward the Ru Creek. The first tract in a length of 375 m shows a vein of up to 8 m width. At 7, a vein fissure is visible, pinching out upwards and running into the hill.

A zone of calcite-filled fissures continues from here in the same direction for about 1100 m, across the elevation SE of the Gemofika hill, but no trace of an asphaltic substance was observed in this zone.

On the northeastern side of the elevation, already in the Middle Şırnak fm., the vein appears again. It can be pursued for 150 m. In the trench no. 12 a vein width of 11 m was measured (see Photograph no. 8).

Again the vein disappears below the fissured beds. After a distance of 600 m it appears again, 10 cm wide on the upper part of the slope of a little valley. About 5 m deeper, in the bed of the creek (in 13 of Fig. 5, right), it is again 1.8C m wide.

Supposing that the Nivekara vein represents one vein, partly open (on the surface), partly covered in depth, it has a total length of 2225 m with a maximum width of 11 m. The dip of the vein could nowhere be measured exactly, but it appears to dip fairly steeply SE.

Only at 12 a sample could be taken which appeared to be less weathered. According to F. Orhun (33, table IV), it is likewise an «asphaltic pyrobitumen associated with mineral matter».

14. The Gündüküremo vein. — In searching for occurrences of asphaltic substances on the north slopes of the "Cudi Mountain in the autumn of 1966, A. Gülay and E. Ercan observed a vein, about 100 m long, in a rivulet in layers of the Cudi group about 300 m south of the gendarme station of Gündüküremo village (Plate I, in 14) (25). The width of the vein is about 5 m.

The asphaltic material is used by the gendarmes and partially by local people of the remote village as «domestic coal».

According to the tests of F. Orhun (33, table IV), it is an «asphaltic pyrobitumen associated with mineral matter».

15. The Dergül veins. — In 1934 Moses (31) announced «asphalt stringers in limestone» from Deirgule, the Dergül of to-day. Clapp (11) termed the occurrences «seepages». The same occurrences were visited by the author (16) in 1964. 1750 m SE of Dergül village, a vein of 5-10-cm width of asphaltic substance is running parallel to calcite veins in ESE direction and dipping 70° S for about 200 m, crossing the marl ridges of Şırnak fm. In the incisions between the naked ridges widths of more than 25 cm were found.

About 1000 m further east, that is about 2700 m SE of Dergül, there appear two veins crossing one another at nearly 90°. One strikes about E-W and is 0.50 to 1 m wide, the other one has nearly N-S direction and shows only as a small ribbon. At the crossing point of the two veins the width is 3.50 m.

In the author's opinion these veins are only the uppermost ends of a larger occurrence in depth.

The fairly hard asphaltic substance was not tested, but it is supposed to be an «asphaltic pyrobitumen associated with mineral matter».

16. The Navyan vein. — South of Navyan village (see Plate I, 16), there exist some outcrops of a 20-25-cm wide vein of a hard asphaltic material, which is supposed to be an «asphaltic pyrobitumen associated with mineral matter». The outcrops, distributed within a distance of 300 m in fairly disturbed layers of the Upper Germav fm., were found during prospecting work in 1965 (17).

c. Vein occurrences in areas cut into pieces by faults

17. The Şikeftikan vein.— North of Kerburan, residence of the district administration (Midyat County, Mardin Province), more exactly N and NE of Şikeftikan village, there is an area of anticlinal structure (Kupraz anticline) cut into pieces by faults, in which the beds of Gercüş fm. appear below Midyat limestones. In Plate I the geological features are shown according to the records of Esso Standard Inc.

During prospecting work in 1964 (16, 17), about 1.5 km NE of Şikeftikan village, an occurrence of asphaltic substance was observed in the typical red sandstones and gypsum-bearing clays of Gercüş fm. (Fig. 6). The small ends of a vein

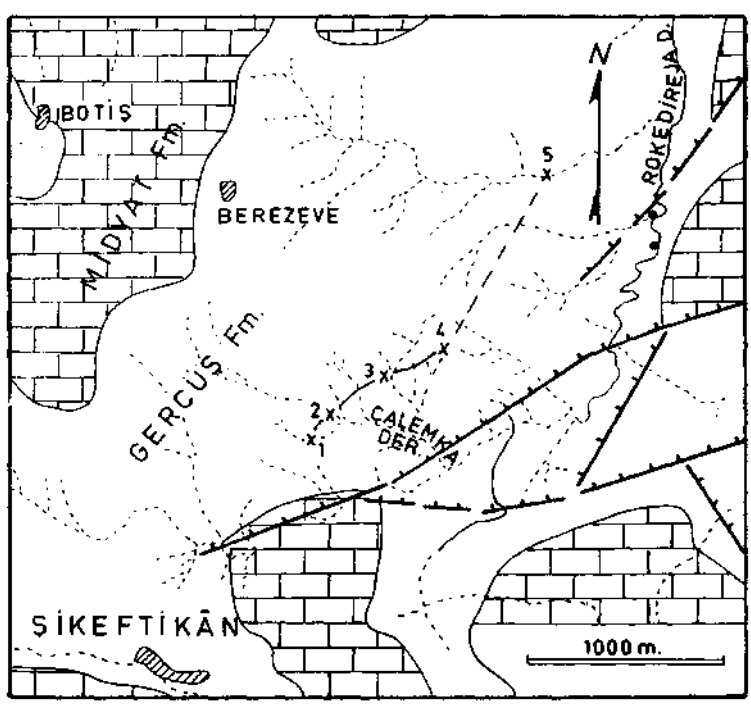

Fig. 6 - Sketch map of Şikeftikan vein (Mardin-Midyat-Kerburan) (see Plate I, 17).

are there exposed by erosion at four places in deep-cut rivulets. The vein is visible in a fissure of 20-30-cm width running upwards and pinching out on the steep slope of the rivulet. In a trench, dug in the Çalemka Creek, the vein

appeared 80 cm wide at one meter depth below the bottom of the creek. Therefore it is very probable that the vein grows wider with increasing depth. The vein dips fairly steeply NW, strikes about SW-NE and has a length of 875 m between the outcrops.

About 1000 m farther NE, pieces of the same asphaltic material were found in the talus. It can be assumed that the vein extends considerably farther, since the extended area of Gercüş fm. is full of fissures and little disturbances. Including this fissure zone, the length of the vein would be about 1800 m, at least.

This occurrence is of special interest because the asphaltic substance is nearly free from mineral matter (only 3.1 %). F. Orhun (33, table IV) placed the material into the group of «substance between asphaltite and asphaltic pyrobitumen (in a pure state)».

C. OCCURRENCES OF ASPHALTIC PYROBITUMINOUS SHALES

During prospection for occurrences of asphaltic substances and examination of several reported outcrops on the north slope of the Cudi Mountain, it became apparent that the limy-dolomitic layers of the Cudi group, which correspond to the oil-bearing «massive limestone» in the area of Diyarbakır, contain a horizon of pyrobituminous limestone, dolomite and shale, at least up to 10 m thick. Beer (8), prospecting for phosphate in the Cudi-Mountain area and in the complexes of the Cudi group, adjoining E and NE, could trace this horizon for more than 70 km. Also Altınlı (2) reports black, very bituminous shales in Mesozoic limestones of Hilal, Gerur and Gündük, which were originally oil-bearing, and had lost their hydrocarbons on exposure at the surface.

The approximate outcrop line of the above-mentioned horizon was drawn according to the records of Beer in Plate III. Referring to 8 points (18-25) shown on the map a few short notes are added as follows:

18. On Ç*ekokalesi* black fetid shales between limestones of the Cudi group were found by T. Ünyay in 1965.

19. In *Tahtadizgehi Creek,* between limestones and dolomites of the Cudi group, in two places (at 1480 m and 1630 m altitudes) a black lime-shale horizon, appr. 8-10 m thick, was found by the author in 1964 (16).

    The material was tested by F. Orhun (33, table IV) and termed «asphaltic pyrobituminous shale». One of the samples contained the astonishing amount of 64.5% of non-mineral matter.

20. The same horizon crops out above *Gülündür village.*

21. Near *Gündüküremo,* about 100 m east of the vein occurrence 14 of Gündüküremo, the same horizon was found by A. Gülay and E. Ercan.

22. On the *Cudiziyaret Mountain and*

23. On the *Dustig Mountain* the horizon can be perceived in parts already from afar.

24. In the *Muhrina Mountains* and

25. Near the *Hilalköy Yaylası,* where dark-grey bituminous shales are found between limestones, samples were taken by N. Yasak.

With the exception of the occurrences of Tahtadizgehi Creek, the tests of the samples yielded only small amounts of asphaltic pyrobitumen, up to 10 %. Nevertheless, it seems very probable that the complex of the Cudi group contains a former oil horizon, which is preserved on the surface only as an «asphaltic pyrobituminous shale» horizon.

III. THE ORIGIN OF VEINE-LIKE OCCURRENCES OF ASPHALTIC SUBSTANCE

There is a general consent of opinion that asphaltic substances are derivated from mineral oil, former asphalts; and the primary beds in which they originated must be found somewhere in deeper formations. Rock movements, caused by tectonic events, produced cracks and fissures, in which soft asphalt masses under the pressure of the load of overlying rocks were squeezed upward. The vein character of the above described occurrences can be regarded as sufficient evidence. Abraham (1) has discussed nearly all possibilities of the origin of vein occurrences and also mentioned all occurrences of the world, as far as he could find them in publications, including the occurrence of Harbol.

As can be gathered from the grouping of the described occurrences, we can distinguish two main types in SE-Turkey :

1. Occurrences originated *in and below an over- or upthrust plane.* In connection with the warping of the sediment layers, cracks and open fissures originate, as shown in Fig. 1 and 2.

2. *In the hanging part of an overthrust.* The question will not be discussed, which part was moved. In any case, the movements resulting from horizontal pressure produced tensions and caused deep-reaching diagonal fissures to open in weak zones. These open fissures were sometimes filled by asphaltic substances. In addition, transcurrent fault-like phenomena are observed, for instance in the southern part of the Segürük veins.

The origin of one of the occurrences is not yet sufficiently cleared up. The territory in which the Şikeftikan vein was found, was thought to be cut into pieces by ordinary faults. The origin of this vein remains an open question which must be postponed for a later more detailed tectonic research.

IV. DIFFERENT CHARACTER OF THE ASPHALTIC SUBSTANCES

As was shown in the examinations of the asphaltic substances by F. Orhun (33), the degrees of metamorphosis of the parent-matter are different. F. Orhun has distinguished the following groups :[3]

A - Substance between asphaltite and asphaltic pyrobitumen (in a pure state).

B - Substance between asphaltite and asphaltic pyrobitumen (associated with mineral matter).

C - Substances having characteristics close to asphaltic pyrobitumen (associated with mineral matter).

D - Asphaltic pyrobitumen (associated with mineral matter).

In Plate I the individual occurrences are distinguished by signs which indicate the kind of asphaltic substance present. The distribution of these kinds or groups in the occurrences is given in the following table. In the same table, the types of geological origin and the respective amounts of mineral substance in percent, according to F. Orhun (33, table IV), are entered, which will be discussed further below.

Geological origin type	*Occurrence*		*Kind of asphaltic substance*	*Mineral substance in % (F. Orhun, 33, table IV)*
	no.	*name*		
In or below an over- or upthrust plane	1	Harbol	B	21.7-30.0
	2	Beşiri	D	46.2
	3	Kasrok	B	39.8
	4	Kâlük-Şivit	D	64.0
	5	Gercüş	B	62.2
In the hanging part of the Cudi overthrust	7	Avgamasya	C	34.8-42.5
	8	Segürük	C	52.8
	9	Milli	D	50.2
	10	Herbiş	D	53.4
	11	Seridahli	D	36.6
	13	Nivekara	D	45.9
	14	Gündüküremo	D	39.9
In a territory dissected by faults	17	Şikeftikan	A	3.1

As becomes evident from the table, the less metamorphic substances B are found in occurrences below an over- or upthrust plane. No doubt, the samples of 2-Beşiri and 4-Kalük-Şivit show a much higher metamorphosis, but that may be due to the fact that they were taken just below the surface, where they had been exposed to the influences of the weather. On the other hand, the samples from trench no. 7 in the bed of Bilmat Creek (Avgamasya vein, Plate IV) show no difference in the degree of metamorphosis from the samples taken in drilling no. 1 and 1A (see F. Orhun - 33, table IV).

The asphaltic substances of the veins in the hanging part of the Cudi overthrust show a higher degree of metamorphosis, only in the Avgamasya vein and in the Segürük veins the asphaltic substance is not so strongly metamorphic.

In spite of that, there is no real connection apparent between the degree of metamorphosis of the asphaltic substances and the type of origin of the vein-occurrences. The question what kind of powers have caused and more or less accelerated the metamorphosis, and whether and to what degree the mineral sub-

stances have acted as catalyzers cannot be answered by the author. Subsequent movements of the rocks, which have accelerated the metamorphosis by pressure in different degrees, can be assumed, but not proved, so far.

An other question is *the high content of mineral substance* in the asphaltic substances. According to the above-named table, a relation between the mineral content and the degree of metamorphosis is not apparent. The question is, why most of the occurrences of asphaltic pyrobkumen in the whole world, mentioned by Abraham (1, pp. 255-267), contain so small amounts of mineral substance, and the occurrences of Southeastern Turkey so much.

Before the question of the high content of mineral substance can be discussed, some important facts and observations are to be mentioned :

1. During the formation of the oil- and also of the asphalt horizon, mineral substance was deposited too. The percentage of mineral substance can vary from place to place. The opinion of Abraham (1, p. 69) that «colloidal mineral particles were held in suspension by the bituminous constituents» appears plausible.
2. In the drilling no. Y1e in the Avgamasya vein, a fissure of 4 cm width was cut in 55.60 m depth in the wall rocks between two vein branches. It was filled out by a seemingly clean asphalt (see Plate IV, profile 11 in «A»). In the hot weather of that time it became soft and had the same composition as the material of the numerous occurrences of asphalt in thin fissures (seepages) shown in Plate I. In other drillings in the Avgamasya vein too, thin fissures filled with asphalt (see Plate IV, profiles 6, 10, 11 and 12 in «A») were found.

   In drilling no. 3A in the Avgamasya vein, an even fracture in a drill-core in marls was found covered by a thin film consisting of an oil-smelling substance (see Plate IV, profile 6 in «Ç»).
3. Some values taken from plate II (drilling no. 1 in the Avgamasya vein) of F. Orhun (33) show how the content of mineral substance and concurrently the specific weight increases with depth:

Depth (in m)	*Mineral substance (in %)*	*Specific weight*
21.65 - 37.45	34.81	1.570
76.75 - 95.35	41.83	1.664
131.55 - 147.65	42.00	1.698
159.20 - 170.00	42.53	1.709

Disregarding the high contents of mineral substance of 50-64 % in the occurrences of Kalük-Şivit, Gercüş., Milli, Herbiş, and Nivekara, in which doubtless a certain amount can be ascribed to the influence of the weather (at shallow depth), there still remains Segürük, showing 52.8 % mineral substance. According to the author's opinion there are only two interpretations :

1) The channel at depth was wide enough to be inefficient as a «filter» and left enough space for the viscous asphalt mass to quickly fill in the fis-

sure until close to the surface. In this case it is not necessary to assume a suspension of colloidal mineral particles.

2) Supposing on the other hand that the channel at depth was narrow, the distribution of the mineral particles in the asphaltic substance must have been so fine that it was impossible for any kind of a «filter» to separate the two substances from one another.

The observations described in 2) speak against the second interpretation. The first interpretation seems to be more plausible. In this way it would be easier to explain that the amount of mineral substance slowly but constantly increases with depth (drilling no. 1 in Avgamasya vein). One can imagine that the heavier mineral particles were slowly sinking in the still half-liquid mass, or else that coarser particles were not carried as far as the uppermost portions of the vein, in the ascending asphalt mass. The excessive amounts of mineral substance in some occurrences might simply reflect the proportion of admixture in the primary oil horizon or its asphalt residue. The exceptionally small amounts of mineral substance in the material of the Şikeftikan vein could find an explanation in this way, too.

One may assume that a filtration took place which permitted liquid material to enter the thin fissures and cracks in which non-metamorphic asphalt material was observed, or else, that locally in the asphalt horizon or in a wide vein a kind of «clearing» of the still highly fluid asphalt-«emulsion» took place, and the cleaned substance ascended in the fissures.

V. CALCITE AND PYRITE IN THE ASPHALTIC SUBSTANCE

The essential characteristics of the vein-like asphaltic substances were found out and described by F. Orhun (33, table II and IV). Only two interesting points shall be shortly discussed:

1) Colloidal mineral particles in suspension in a bituminous groundmass, the soft asphalt, were mentioned above. During the chemical processes of alteration the mineral substance, too, was re-grouped. New calcite crystals were formed. The two thin slides in Photograph 11 and 12 show idiomorphic and xenomorphic calcite crystals in sizes of 0.01 to 0.1 mm in an asphaltic groundmass. But single crystal-aggregates may grow to a length of up to 7. cm, as can be seen in the two drill-cores in Photograph no. 10.

2) In the descriptions of occurrences of asphaltic substances, reference was repeatedly made to burned vein parts, long brick-red belts consisting of scoria (with grey-black coke in between), fritted marls and sintered sandstones, and also a section in the Segürük veins which is still burning to-day. It is not necessary to assume that the burning was everywhere caused by human activity. The fact that old burnt vein parts are found in the Avgamasya vein area below terrace gravels 2-3 m thick, is evidence for self-ignition. The gravels are supposed to have Pliocene-Pleistocene age.

The answer to the question of self-ignition is rather simple. The total sulphur content was found to average 7.3 % in-drilling 1 of the Avgamasya vein, 6.3 % in drilling 1A, and 5.4 % in trench no. 7. In polished sections, though not in thin slides, numerous grains of pyrite (not marcasite) are recognizable in sizes from 0.001 to 0.005 mm. Since the asphaltic substance also contains mineral substance in amounts of 39 to 42 %, the pyrite can be assumed to act as a catalyser as it does in outcrops of lignites.

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* Only for practical reasons, to avoid long names the abbreviation «asphaltite» was applied for metamorphic asphaltic substances in the reports of Nebert and Lebküchner.

Photo 1 - View from about E to the upper part of the Harbol Valley below the Giri Azman Mount. M - Steeply dipping Midyat limestones; G - Steeply dipping red sandstones of the Gercüş fm ; A - Collapsed trench in the vein; The dotted line shows the approximate outcrop-line of the vein below the talus.

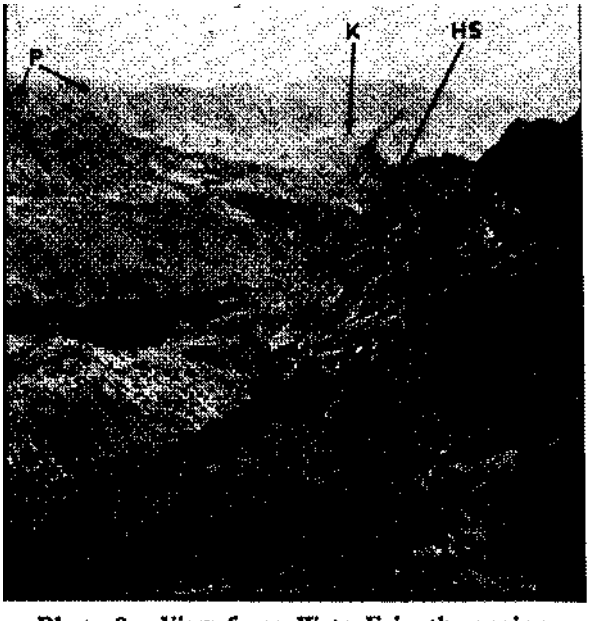


Photo 2 - View from W to E in the region of Harbol.

On the right the steep Midyat limestones of the Geren Mountain (Turkey) and the Kera Mountain (Iraq). At HS the breakthrough of the Hezil River, which is the border between Turkey and Iraq. At H Harbol village is situated in the green. The Kasrok occurrence is situated somewhere near K.
P-Permian limestones

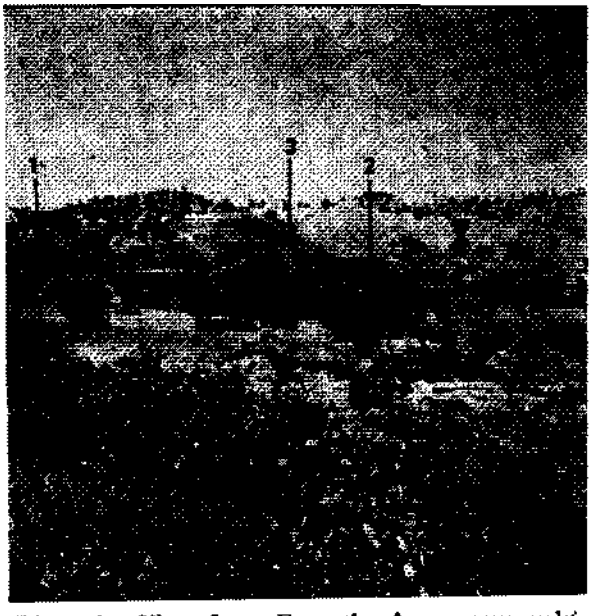


Photo 3 - View from E to the Avgamasya vein.
Open casts. At 1 in the main-vein, shown in profile 8 (Plate IV); at 2 the main vein was exposed near the place where profile 7 cuts it; at 3 in the north-western side vein between profiles 7 and 8 (Plate IV).

Photo 4 - View to NE to the Avgamasya vein.
In the foreground the new open cast in the northwestern side vein. Behind it on the right the decapage works in the main vein. Taken near the point where profile 9 (Plate IV) cuts the side vein.

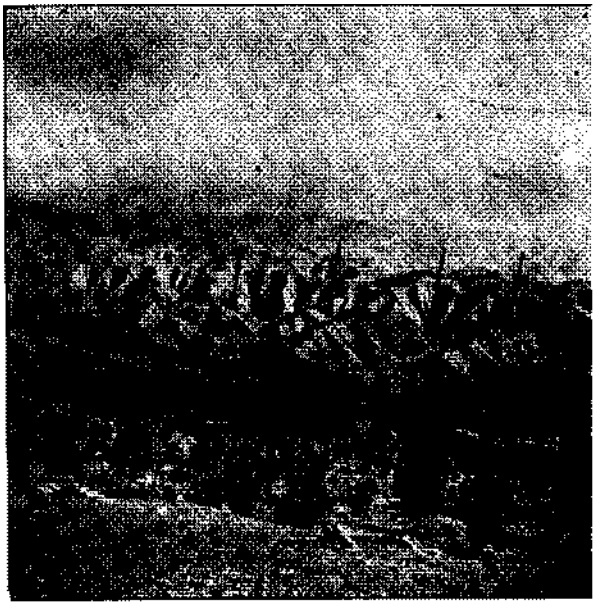


Photo 5 - View to the south from the road of Şırnak-Uludere near Kürün village.

The arrows point at the row of trees upon the outcrop - line of the Milli vein, which cuts the ridges and glens. The most distant summits in the background belong to the Cudi Mountains.

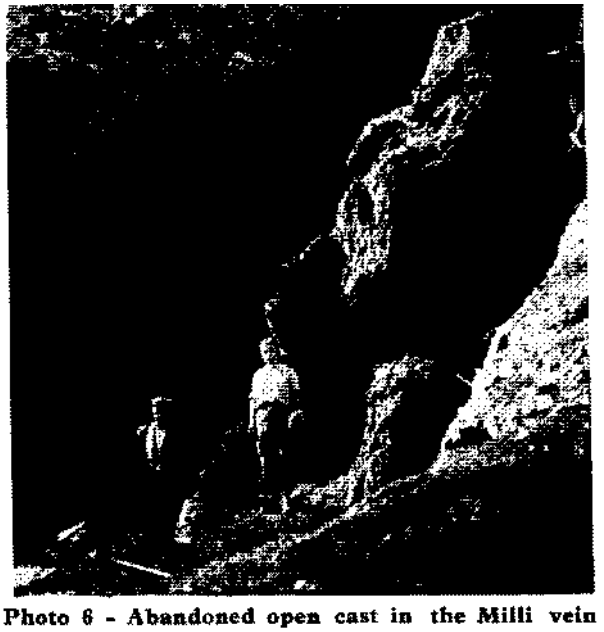


Photo 6 - Abandoned open cast in the Milli vein (point 12 in Plate VI) showing the dividing wall of marl.

Photo 7 - View from N to Seridahli vein, which is marked by a cluster of trees upon the vein-outcrop-line (arrows).

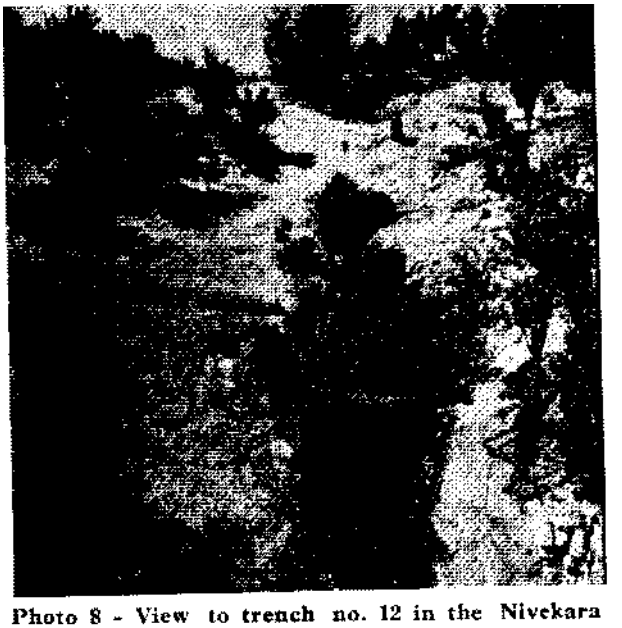


Photo 8 - View to trench no. 12 in the Nivekara vein.

Photo 9 - Drilling core of the asphaltic material with fragments of marl, once dropped into the soft asphalt mass and slightly infiltraded by it, showing clearly recognizable stratification.

Photo 10 - Drilling cores of asphaltic material showing newly-formed calcite-crystal-aggregates (up to 7 cm) (white) **and a fragment of marl infiltrated by asphalt.**

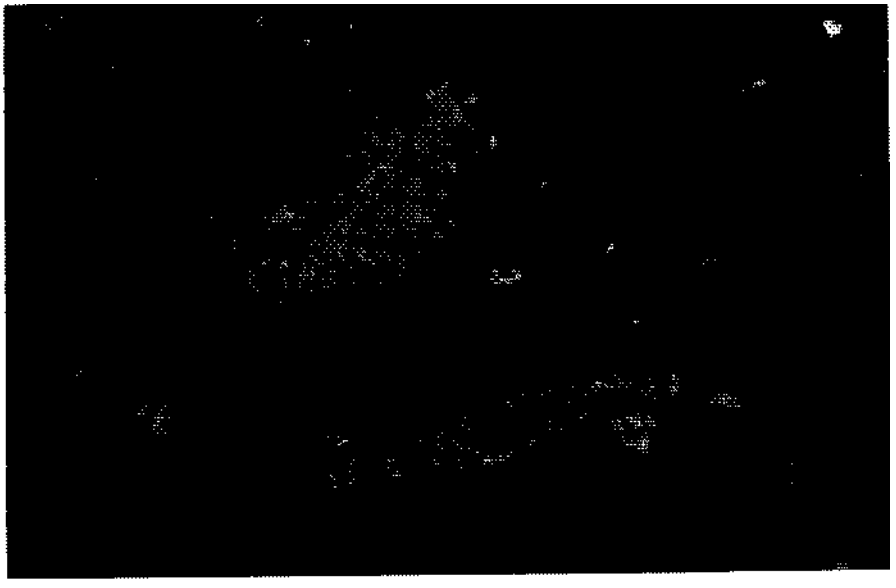


Photo 11 - Thin slide (no. 46 711) of a drilling core of the Avgamasya vein showing newly-formed crystals of calcite in the asphaltic mass with sizes up to 0.1 mm (250 × enlarged).

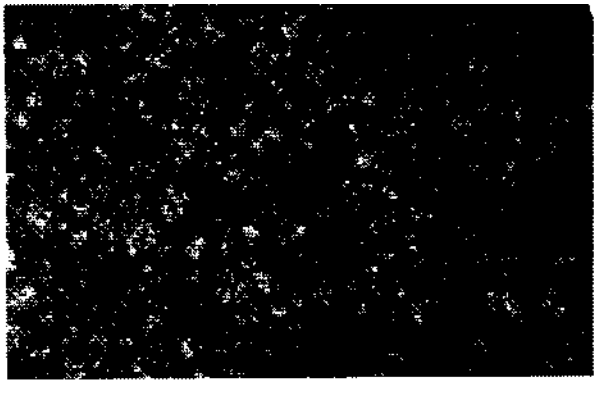
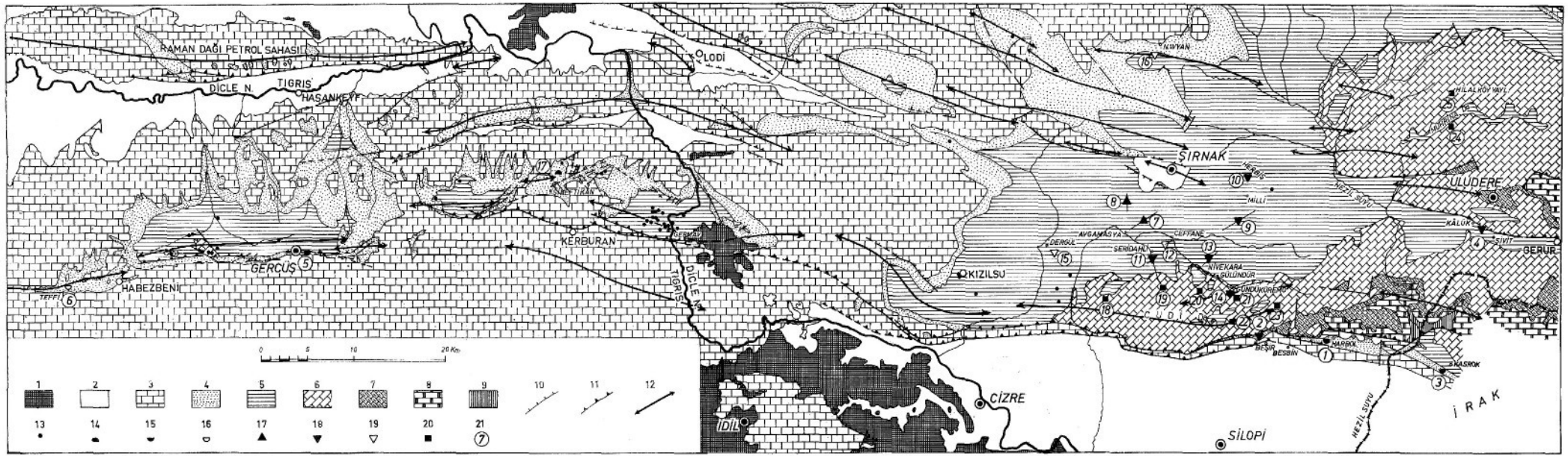
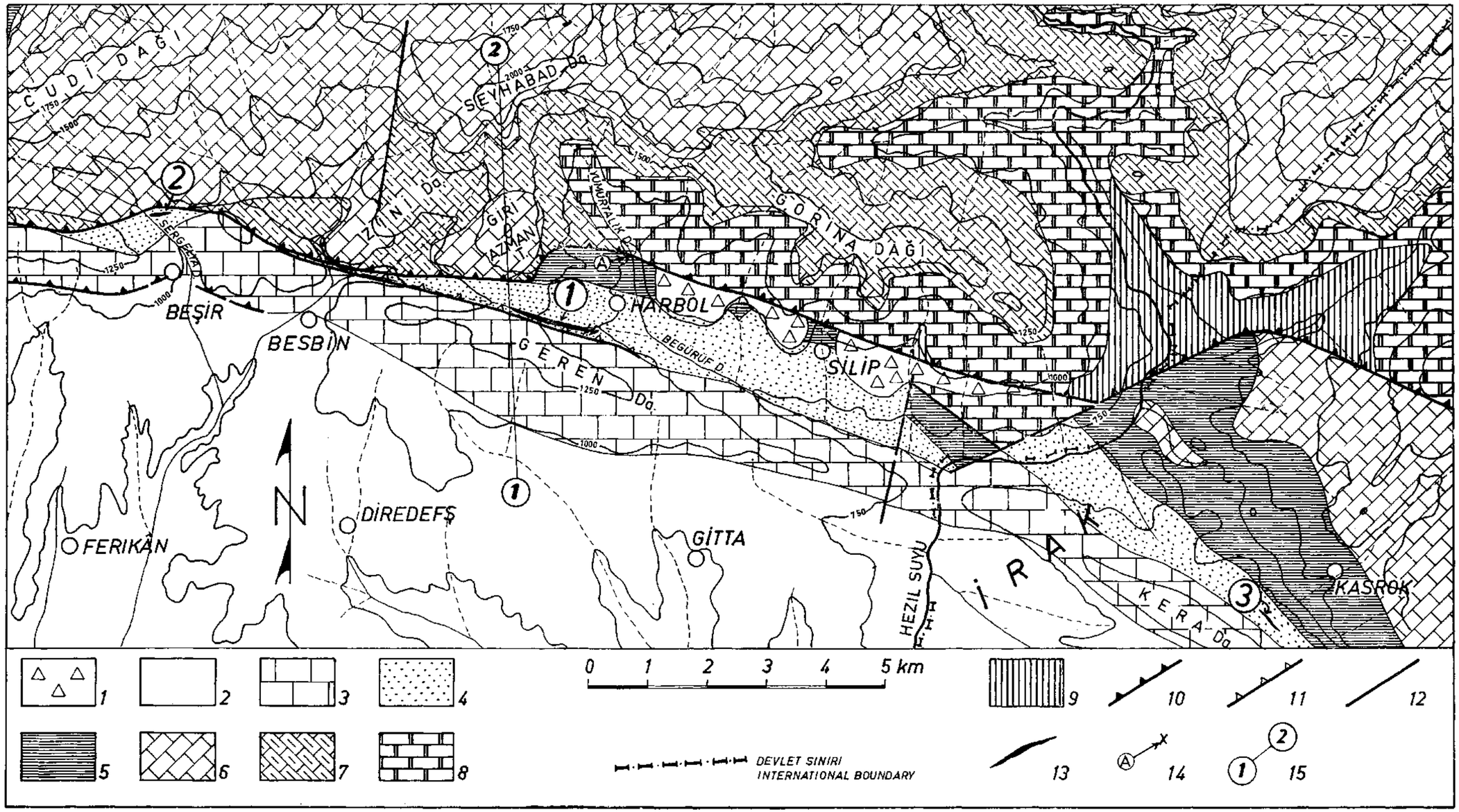


Photo 12 - Thin slide (no. 46 712) of a drilling core of the Avgamasya vein showing newly-formed small and tiny crystals of calcite in the asphaltic mass, with sizes of about 0.01 mm (250 × enlarged).



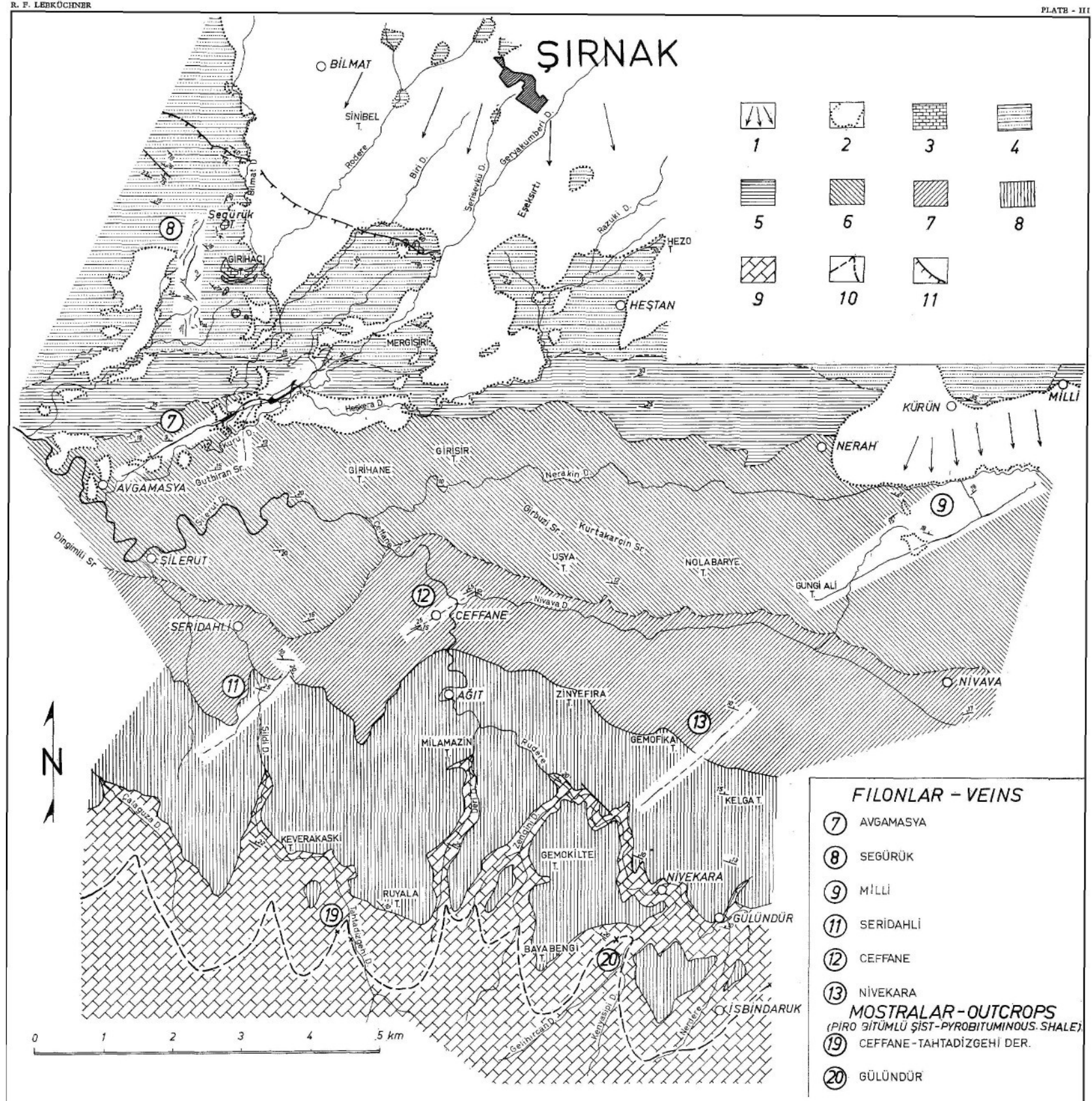
GEOLOGICAL OUTLINE MAP OF SOUTHE ASTERN TURKEY WITH THE OCCURRENCES OF ASPHALTIC SUBSTANCES

1 - Basalt; 2 - Neogene and younger formations; *3 - Midyat fm.* (Middle Eocene); *4 - Gercüş fm.* (Paleocene-Lower Eocene); *5 - Germav fm. - Becirmen Limestone* (Upper Cretaceous-Paleocene); *6 - Cudi group* (Middle Triassic? - Jurassic - Cretaceous); *7 - Goyan group* (Lower-Middle Triassic); *8 - Harbol fm.* (Permian); *9* - Devonian; *10 - Faults; 11 - Overthrust and upthrust; 12 - Anticline axes; 13 - Asphalt exsudations; 14 - Substance between asphaltite and asphaltic pyrobitumen* (in a pure state); *15 - Substance between asphaltite and asphaltic pyrobitumen* (associated with mineral matter); *16 - As 15. No samples taken. 17 - Substances having characteristics close to asphaltic pyrobitumen* (associated with mineral matter); *18 - Asphaltic pyrobitumen* (associated with mineral matter); *19 - As 18. No samples taken; 20 - Asphaltic pyrobituminous shale; 21 - Occurrences described.*



GEOLOGICAL SKETCH MAP OF THE VEINS OF HARBOL AND BEŞİRİ (MARDİN-SİLOPİ) AND KASROK (IRAQ)

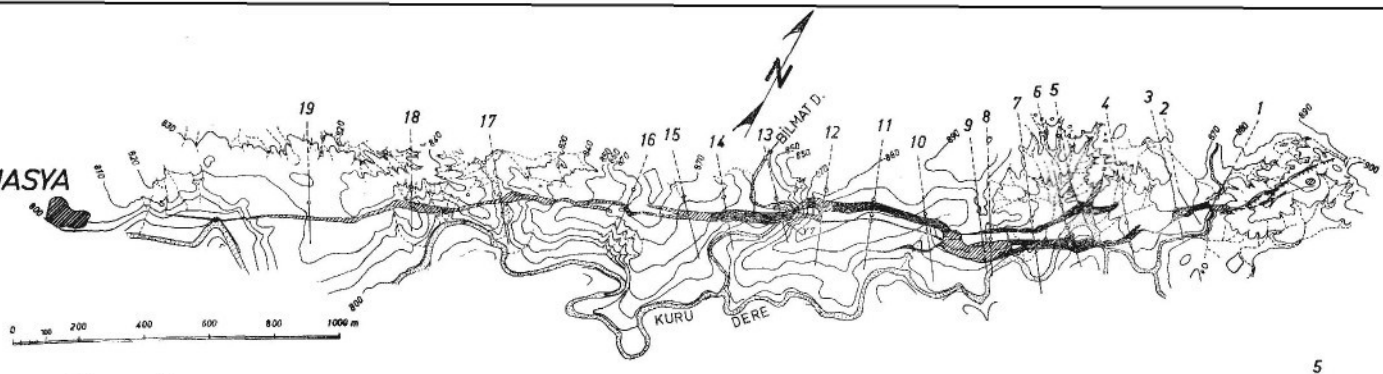
1 - Talus; 2 - Neogene, undifferentiated; 3 - Midyat fm. (Middle Eocene)*; 4 - Gercüş fm.* (Paleocene-Lower Eocene)*; 5 - Germav fm.* (Upper Cretaceous-Paleocene)*; 6 - Cudi group* (Middle Triassic? - Jurassic - Cretaceous)*; 7 - Goyan group* (Lower-Middle Triassic)*; 8 - Harbol fm.* (Permian)*; 9* - Devonian*; 10 - Overthrust: 11 - Upthrust; 12 - Fault; 13 - Vein* (thickness of line does not correspond to width of vein)*; 14 - Outcrop of a vein of asphaltic pyrobitumen in the overthrust-plane; 15 - Profile line* (see Fig. 1).

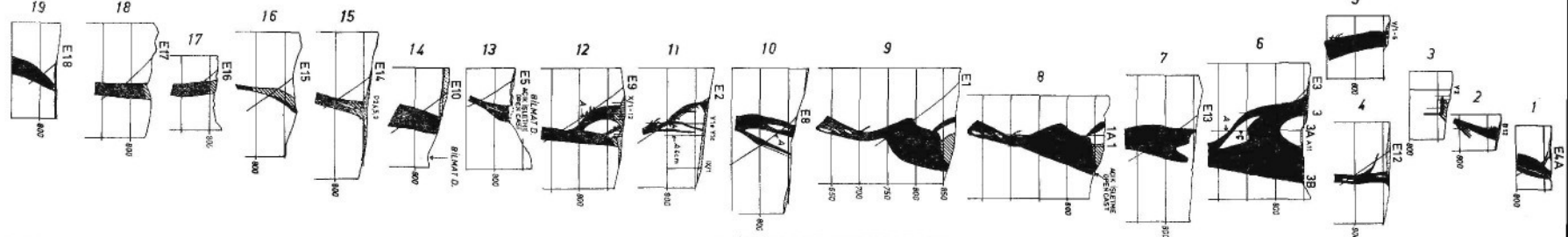


GEOLOGICAL SITUATION SKETCH OF THE VEINS OF ASPHALTIC SUBSTANCES BETWEEN ŞIRNAK COUNTY (PROVINCE SİİRT) AND THE CUDİ MOUNTAIN

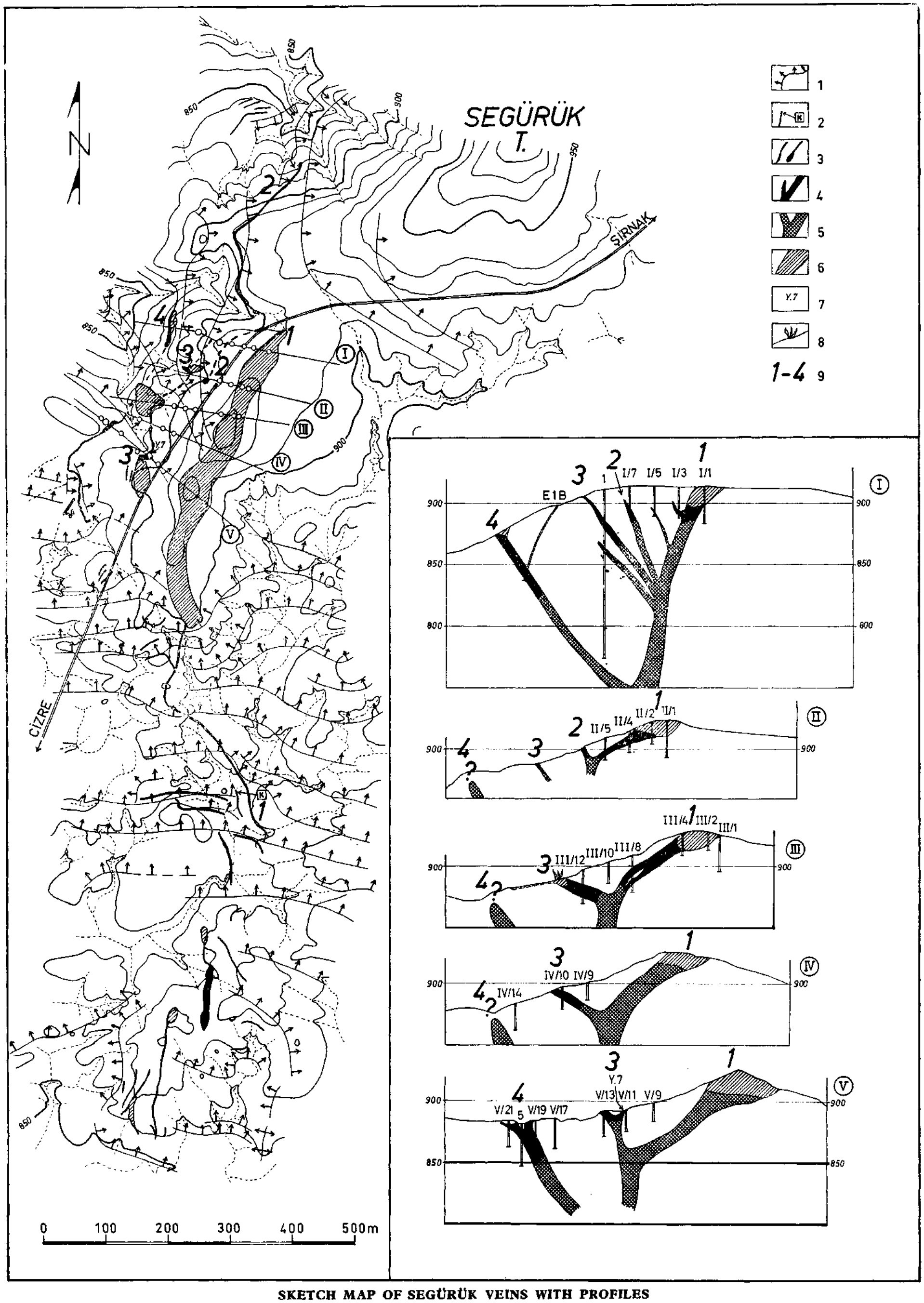
FORMATIONS	*LITHOLOGY*	AGE DIVISIONS
1 - Main-landslip areas	*Squashed marl and sandstone, gigantic boulders of Becirmen-limestone*	Quaternary
2 - Terraces	*Sandy-loamy gravels*	Pliocene
3 - BECİRMEN-LIMESTONE	*Bluish-grey limestone*	
4 - UPPER GERMAV fm.	*Dark grey, well-bedded marls with hard sandstone layers*	
5 - LOWER GERMAV fm.	*Soft, greenish-grey marl*	Maestrichtian
6 - UPPER ŞIRNAK fm.	*Alternating compact hard limestones and bluish-grey, soft marls*	
7 - MIDDLE ŞIRNAK fm.	*Alternating cherty marl and soft clayey marl*	
8 - LOWER ŞIRNAK fm.	*Alternating harder marly limestones and soft marls*	Campanian
9 - CUDİ GROUP	*Limestone, dolomite, shale (partially pyrobituminous)*	Jurassic - Middle Triassic

10 - Approximate outcrop line of the asphaltic pyrobituminous shales
11 - Fault



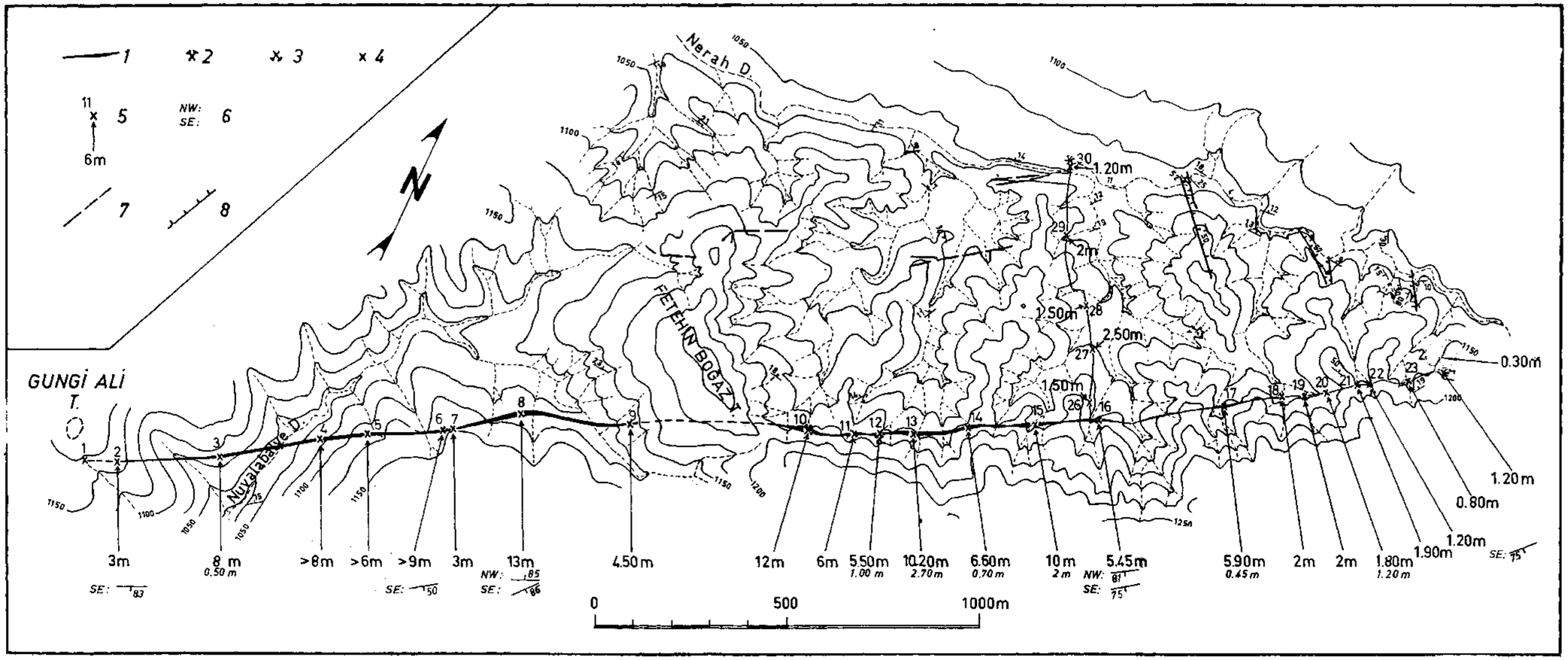


SKETCH MAP OF AVGAMASYA VEIN WITH PROFILES



SKETCH MAP OF SEGÜRÜK VEINS WITH PROFILES

1 - Variation in strike and dip of strata; 2 - Typical apparition of tectonic deformation (see explanatory text and figure no. 4); *3 - Vein* (map). *Thickness of line does not correspond to width of vein; 4 - Proved portions of vein; 5 - Assumed portions of vein; 6 - Burned matter* (scoria, red burned marls, etc.); *7 - Trench number 7 - location of samples taken; 8 - Vein outcrop, burning since more than 40 years; 9 - Most important veins or portions of veins discussed in text.*



SKETCH MAP OF THE MİLLİ VEIN

1 - Vein (thickness of line corresponds approximately to width of vein); *2 - Mines; 3 - Abandoned mines; 4 - Trenches; 5 - Width of vein in trenches and mines; 6 - Strike and dip of the sidewalls of the vein in trenches and mines : NW-NW wall, SE-SE wall; 7 - Major calcite-filled fissures; 8 - Faults.

Table I

The most important distinguishing characteristics of the asphaltic substances in the world

Characteristic properties	*Petroleum*			*Natural asphalts (<10% mineral matter)*	*Asphaltites*			*Asphaltic pyrobitumens*		
	Non-asphaltic	*Semi-asphaltic*	*Asphaltic*		*Gilsonite*	*Glance pitch*	*Grahamite*	*Wurtzilite*	*Albertite*	*Impsonite*
Color in mass	Brown to black	Brown to black	Black	Black	Black	Black	Black	Black	Brown to black	Black
Fracture	—	—	—	Conchoidal to hackly	Conchoidal to hackly	Conchoidal to hackly	Conchoidal to hackly	Conchoidal	Conchoidal to hackly	Hackly
Lustre	—	—	—	Very bright to dull	Very bright to fairly bright	Bright to dull	Bright to dull	Bright	Bright to dull	Semidull
Streak	—	—	—	Dark brown to black	Brown	Brown to black	Black	Light brown	Brown to black	Black
Specific gravity (Test 14, IV)	0.75-0.90	0.80-0.95	0.85-1.00	0.95-1.12	1.03-1.10	1.10-1.15	1.15-1.20	1.05-1.07	1.07-1.10	1.10-1.25
Hardness on Mohs' scale	—	—	—	<1-1	2	2	2-3	2-3	2	2-3
Penetration at 77°F (Test 19)	Liquid	Liquid	Liquid	0-350	0-3	0-5	0	0-5	0	0
Fusing point, °F (Test 32)	<32	<32	<32	60-325	250-350	250-350	350-600	Infusible	Infusible	Infusible
Fixed carbon, % (Min. matter-free basis) (Test 43)	0.5-2	2-5	5-10	1-25	10-20	20-35	35-55	5-25	25-50	50-85
Oxygen, % (Min. matter-free basis) (Test 54)	0-2	0-3	0-5	0-2	0-2	0-2	0-2	0-2	0-3	0-3
Mineral matter, % (Test 44)	0-1	0-1	0-1	0-10	Tr.-1	Tr.-5	Tr.-50	Tr.-10	Tr.-10	Tr.-10
Solubility in CS_2, % (Test 44)	98-100	98-100	98-100	90-100	98-100	95-100	45-100	5-10	2-10	Tr.-6
Solubility in CS_2, % (Min. matter-free basis)	98-100	98-100	98-100	94-100	99-100	97-100	90-100	5-10	2-10	Tr.-6
Non-mineral matter insoluble in CS_2, % (Test 44)	0-0.5	0-1	0-1	0-6	0-1	0-3	0-5	85-95	85-98	93-99
Non-mineral matter insoluble in CS_2, % (Min. matter-free basis)	0-0.5	0-1	0-1	0-6	0-1	0-3	0-10	90-95	90-98	94-100
Solubility in petroleum naphtha, % (Test 46, I)	98-100	95-100	90-100	10-90	10-60	15-50	Tr.-50	Tr.-2	Tr.-2	Tr.
Carbenes, % (Test 45)	0-0.5	0-1	0-1	0-5	0-0.5	0-1	0-80	Tr.-2	Tr.-2	Tr.-2
Sulfonation residue, % (Test 60)	90-100	85-95	80-95	90-100	85-95	85-95	80-95	90-98	90-98	90-98
Diazo reaction (Test 63)	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
Anthraquinone reaction (Test 64)	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative